



Iowa Department of Transportation

DEVELOPMENTAL SPECIFICATIONS FOR MASS CONCRETE – CONTROL OF HEAT OF HYDRATION

Effective Date
August 17, 2010

THE STANDARD SPECIFICATIONS, SERIES 2009, ARE AMENDED BY THE FOLLOWING MODIFICATIONS AND ADDITIONS. THESE ARE DEVELOPMENTAL SPECIFICATIONS AND THEY SHALL PREVAIL OVER THOSE PUBLISHED IN THE STANDARD SPECIFICATIONS.

09047.01 DESCRIPTION.

Produce a structure free of shrinkage cracks that would be a result of heat of hydration during the curing of large concrete cross-sections. Accomplish this through appropriate concrete mix design and management of concrete temperature and temperature differential. Structural mass concrete is defined as any concrete footing with a least dimension greater than 5 feet (1.5 m) or other concrete placements with a least dimension greater than 4 feet (1.2 m). Additional constraints are required on placements with a least dimension greater than 6.5 feet (2 m). This specification does not apply to concrete drilled shafts.

Apply Section 2403 and Division 41 of the Standard Specifications with the following modifications.

09047.02 MATERIALS.

- A. Cement shall be Type I/II, IP, or IS.
- B. Use any combination of Ground Granulated Blast Furnace Slag or Class F fly ash. Class C fly ash may also be used with a maximum substitution of 20%. The maximum total substitution of Portland cement shall not exceed 50%, including the amount in the blended cement.
- C. Cement content shall be a minimum of 560 pounds per cubic yard (332 kg/m³).
- D. Maximum water to cementitious ratio shall be 0.45.
- E. Air entrainment shall be used. To improve workability and aid in air entrainment, water reducing or retarding admixtures may be used. A mid range water reducing admixture may be used and the slump shall be increased to six inches maximum.

09047.03 CONSTRUCTION.

A. THERMAL CONTROL PLAN.

Develop and submit a written Thermal Control Plan describing the procedures that will be used during the period of heat dissipation following concrete placement, so the temperature differential between the interior of the section and the outside surface of the section does not exceed the restrictions in Article 09047.03, B. Submit the Thermal Control Plan at least 30 calendar days before the first intended structural mass concrete placement.

Compliance with this specification may result in long cooling times. Consider options to control

heat of hydration that are compatible with their desired construction schedule and erection procedures.

Do not place concrete covered by this specification until the Thermal Control Plan has received written approval by the Engineer and equipment and materials necessary to facilitate the plan are on site and ready for use. Provide and install temperature sensing devices according to Article 09047.03, B, 3.

The location of construction joints shall be as shown in the plans.

For mass concrete placements with a least dimension of less than or equal to 6.5 feet (2 m) the Thermal Control Plan procedures may include, but are not limited to, the following:

- Cooling component materials prior to addition to the mix to reduce the temperature of the concrete while in its plastic state.
- Adding ice to the mix water.
- Sprinkle coarse aggregate with water or wet the stockpile.
- Controlling rate of concrete placement (low lifts).
- Insulating the forms and the surface of the concrete to prevent temperature differential.
- Placing concrete at times of day when the ambient temperature is lowest (in summer) or highest (in winter).
- Other acceptable methods that may be developed by the Contractor and approved in writing by the Engineer.

For mass concrete placements with a least dimension of greater than 6.5 feet (2 m), the Thermal Control Plan shall be developed by a Professional Engineer, licensed in the State of Iowa and competent in the modeling, design, and temperature control of concrete in mass elements (T. C. Engineer). The T. C. Engineer shall submit a list containing at least three mass concrete projects, of similar dimension and thermal control requirements to those shown on the plans, completed in the last three years. In the list of projects include names and phone numbers of owner's representatives who can verify the T. C. Engineer's participation on those projects. The T. C. Engineer shall follow the procedure outlined in Section 207.4R-05 of the ACI Manual of Cooling and Insulating Systems for Mass Concrete to formulate, implement, administer, and monitor a temperature control plan, making adjustments as necessary to ensure compliance with the Contract Documents.

The Thermal Control Plan shall include, but not be limited to the following:

1. Based on the concrete mix design, determine by lab testing the adiabatic heat generation for the concrete mix to be used.
2. Proposed methods to achieve required concrete temperature and control concrete temperature differential through concrete mix design and construction practices for temperature control to prevent thermal cracking.
3. Design of a cooling system consisting of non-corrosive piping to be embedded in the structural mass concrete for all mass concrete placements that are below water level within the limits of the river.
4. Provide information on the temperature sensing and recording equipment to be used and details of installation locations of the temperature probes for each planned mass concrete placement.
5. Mass concrete placement plan to ensure prevention of concrete cold joints.
6. Monitoring Plan to control temperature gradient.

B. THERMAL CONTROL.**1. Concrete Temperature Limits.**

Maximum concrete temperature at time of placement shall not exceed 70°F (21°C) and shall not be less than 40°F (4°C). The maximum concrete temperature during the period of heat dissipation shall not exceed 160°F (71°C).

2. Temperature Differential Restrictions

The temperature differential between the interior of the section and the outside surface of the section shall not exceed the limit in the following table:

Hours after placement	Maximum temperature differential °F (°C)
0-24	20 (11.1)
24-48	30 (16.7)
48-72	40 (22.2)
>72	50 (27.8)

Thermal control of each placement shall be maintained until the temperature of the interior is within 50°F (27.8°C) of the average outside air temperature. The average outside air temperature shall be determined by averaging the daily high and low temperatures over the preceding seven calendar days.

3. Temperature Sensing and Recording

For each placement of structural mass concrete, two temperature sensors shall be installed at each of the following locations (for a total of ten temperature sensors):

- center of the placement,
- midpoint of the side which is the shortest distance from the center (minimum 2 inch (50 mm) cover),
- midpoint of the top surface (minimum 2 inch (50 mm) cover),
- corner of the placement which is furthest distance from the center (minimum 2 inch (50 mm) cover), and
- air temperature.

The purpose for two sensors at each location is to provide a primary and secondary backup.

Temperatures shall be electronically recorded automatically by an approved recorder furnished by the Contractor and shall be capable of continuously recording a minimum of one reading per hour for the duration of the mass concrete temperature monitoring period. Sensors and recorder shall be accurate to within +/- 2°F (1.1°C) in the temperature range of 32°F (0°C) to 212°F (100°C). Provide a backup temperature sensing system, which shall include both backup temperature sensors and backup temperature readout device. Back-up system is intended to be used to complete the monitoring of a placement should the primary system fail. Primary system shall be repaired or replaced before the commencement of the next placement.

C. PRODUCTION CONCRETE.

1. The T. C. Engineer or qualified technician employed by the T. C. Engineer, shall personally inspect and approve the installation of monitoring devices and verify the process for recording temperature data is effective for the first placement of each size and type mass component. Qualifications of all technicians employed to inspect or monitor mass concrete placements shall be submitted to the Engineer for approval. For placements other than the first, an employee, approved by the T. C. Engineer as qualified to inspect monitor device installation, shall be designated to: 1) review temperature data, 2) be in contact at all times with the

Engineer if adjustments must be made as a result of the temperature differential being exceeded, and 3) immediately implement adjustments to temperature control measures as directed by the T. C. Engineer. Recorded temperature data shall be reviewed at intervals of no greater than 4 hours. Recording of temperature data shall begin when the mass concrete placement is complete and shall continue until the maximum temperature differential (not maximum temperature) is reached and a decreasing temperature differential is confirmed as defined in the Thermal Control Plan. If conditions change, such as a drop in the ambient temperature or a change in insulation which would result in an increase in the temperature differential, the recording of temperature data shall be resumed. A copy of all recorded temperature data shall be furnished to the Engineer as they are determined, and a final report shall be furnished within 3 days of completion of monitoring of each element.

Only use approved mixes for production concrete

2. If the temperature differential within any structural mass concrete placement exceeds the limits in Article 09047.03, B , immediate corrective action as directed by the Contractor or the T. C. Engineer shall be taken, future placement of structural mass concrete will be suspended, and a revised Thermal Control Plan shall be submitted to the Engineer for approval. Do not resume placement of mass concrete without written approval from the Engineer.

When mass concrete temperature differentials are exceeded, all analyses and test results deemed necessary by the Engineer shall be provided for determining the structural integrity and durability of the mass concrete element, to the satisfaction of the Engineer. The analyses and/or test results shall be provided at no additional cost to the Contracting Authority and without additional time to be granted.

Based on the analyses and test results, a determination of corrective action will be made by the Engineer which may include, but not be limited to, price adjustment, epoxy injection of thermal cracks, a combination of both, or removal of the non-complying concrete.

09047.04 METHOD OF MEASUREMENT.

None.

09047.05 BASIS OF PAYMENT.

Costs for complying with this specification shall be considered incidental to the contract unit price for structural concrete.